POSSIBLE EFFECTS OF IRRIGATION WITH SAN JOSE - SANTA CLARA WASTEWATER

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by

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Bechtel Inc.

DRAFT

TABLE OF CONTENTS

INTRODUCTION -- 1

1.0 SANTA CLARA COUNTY -- 2

Summary of Effects -- 2

1.1 Present Agriculture in the Santa Clara Valley ----------- 2

1.2 Wastewater Quality Case "A" --------------------------- 5

1.3 Salinity -- 6

General Effects -- 6

Salt Tolerance of Crops ---------------------------------- 8

Effect of Salinity with Project Area ------------------- 10

1.4 High Sodium -- 11

1.5 Specific in Toxicities -------------------------------- 14

1.6 Expected Losses to Farmers --------------------------- 15

1.7 Irrigation with Case C Water ------------------------- 17

2.0 SAN BENITO COUNTY ----------------------------------- 19

Summary of Effect --------------------------------------- 19

2.1 Agriculture and Water Supply ------------------------- 19

2.2 The Bolsa Area --------------------------------------- 21

2.3 Land Reclamation Drainage ---------------------------- 23

2.4 Wastewater Irrigation -------------------------------- 24

REFERENCES --- 26

INTRODUCTION

Wastewater use for irrigation of agricultural crops is on the increase. A survey of nearly 200 California wastewater facilities revealed that in 1976 in nearly 180 instances reclaimed water was used for irrigation. The majority of crops irrigated with this water produced fodder, fiber and seed. Orchards, food crops and dairy pastures were irrigated in a lesser number of cases. The extent of the irrigated area is not available, however, in case of food crops, it definitely is not extensive.

To the present, there is no record that any health problem would have been caused by the use of reclaimed water in this state. However, there is no record of large scale application of wastewater to such diversified crops as are presently grown in the project area.

The disposal of 50,000 acre feet of wastewater has been planned through the irrigation of agricultural crops. The wastewater would come from facilities located in the San Jose area.

The present study explores the possible effects of wastewater irrigation in the Santa Clara Valley and in the San Benito County's Bolsa area. Outlined of the two areas are shown in map 1.

For waste water quality two levels of treatment were assumed (Case A and Case C). The treatment in Case C involves partial removal of major salts.

1.0 SANTA CLARA COUNTY

Summary of effects of wastewater irrigation "Case A"

- The projected wastewater composition indicates a poor quality water for irrigation.
- Salinity, toxic levels of sodium, bicarbonates and chlorides are the objectionable constituents.
- Orchards will be eliminated when no longer profitable to grow them. Tree stands valued at $25 million will be lost ($1500. per acre).
- Reduced yields of vegetable crops would force farmers to change to more salt tolerant crops. In general, the replacement crops will be less profitable to grow.
- High sodium and bicarbonates will reduce soil permeability in most soils. This process can render soils totally barren.

1.1 Present Agriculture in the Santa Clara Valley

Agricultural production in the Santa Clara County is confined to that portion of the Santa Clara Valley which extends from San Jose to the Pajaro River. Therefore, the disposal of 50,000 to 60,000 acft. of wastewater per year, through the application to agricultural crops, must also be confined to this general area.

The wastewater would be discharged from the San Jose - Santa Clara area. Closest to the source lies the area which extends from San Jose to Gilroy. It is a narrow and flat valley, where a wide variety of crops are grown on the alluvial soils. Irrigated lands occupy 27,000 acres in this area. It requires 63,000 acft. of water in a normal rainfall year to irrigate the crops. (Table 1)

Table 1

IRRIGATION WATER REQUIREMENT

Santa Clara County - Project Area		WATER REQUIREMENT	
Crop/Orchards	Acres*	acft./ac/yr.	TOTAL acft./yr.
Apricots	2,419	2.0	4,838
Cherries	721	2.0	1,442
Grapes	1,834	2.0	3,668
Pears	1,474	2.0	2,948
Prunes	7,342	2.0	14,684
Walnuts	3,104	2.5	7,760
Misc. Orchards	390	2.0	780
Total	17,284		36,120
Vegetables			
Anise	10	2.0	20
Beans, Snap	335	2.0	670
Broccoli	50	2.0	100
Cabbage	70	2.5	175
Cauliflower	55	2.0	110
Chinese Vegetables	660	3.0	1,980
Corn	240	2.5	600
Cucumber	440	2.5	1,100
Endive	40	2.0	80
Garlic	500	1.5	750
Lettuce, Head	425	5.0	2,125
Lettuce, Leaf	390	5.0	1,950
Lettuce, Romaine	90	5.0	450
Mustard	50	1.0	50
Onions	305	2.0	610
Peppers, Bell	360	3.0	1,080
Peppers, Chili	315	3.0	945
Spinach	80	3.0	240
Squash	105	2.0	110
Tomatoes, Fresh	85	2.5	212
Tomatoes, Processed	2,500	2.5	6,250
Tomatoes, Cherry	70	2.5	175
Misc. Vegetables	700	2.5	1,750
Total	7,875		21,532
Field			
Alfalfa	230	3.0	690
Pasture	700	3.5	2,450
Sugar Beets	2,120	2.3	2,576
Total	2,050		5,716
Grand Total	27,209		63,368

*Estimated for the north Gilroy area.

Table 2

Acerage Distribution and Production Data *

	ACREAGE			PRODUCTION			
Crops	County Total	North of Gilroy	South of Gilroy	Yield t/a	Unit Price $/t	Gross Income $/ac	Gross Income $1000.
Orchards							
Apricots	2,819	2,419	400	4.86	300	1,458	4,110
Cherries	1,021	721	300	2.92	610	1,781	1,818
Grapes	2,334	1,834	500	3.33	205	682	1,593
Pears	1,774	1,474	300	7.16	129	973	1,638
Prunes	8,342	7,342	1,000	1.39	385	535	4,466
Walnuts	3,704	3,104	600	.65	470	304	1,128
Misc. Orchard	390	390	--	--	--	1,538	600
Total	20,384	17,284	3,100				15,353
Vegetables							
Anise	10	10		8.75	180	1,575	16
Beans, snap	335	335		4.57	370	1,690	566
Broccoli	50	50		2.60	280	728	36
Cabbage	70	70		9.2	80	736	51
Cauliflower	55	55		4.0	240	960	53
Chinese Veg.	660	660		18.0	100	1,800	1,190
Corn	240	240		5.58	160	893	214
Cucumber	1,240	440	800	14.0	120	1,680	2,088
Endive	40	40		9.0	120	1,080	43
Garlic	500	500		5.2	382	1,986	993
Lettuce, Head	625	425	200	10.7	116	1,241	776
" , Leaf	390	390		5.79	173	1,002	391
" , Romain	90	90		15.9	66	1,049	94
Mustard	50	50		4.3	240	1,032	52
Onions	505	305	200	22.6	200	4,520	2,280
Peppers, Bell	860	360	500	9.5	152	1,444	1,242
" , Chili	315	315		6.51	370	2,409	758
Spinach	80	80		5.6	300	1,680	134
Squash	105	105		7.8	162	1,263	133
Tomatoes, Fresh	85	85		19.1	230	4,393	373
" , Processed	8,500	2,500	6,000	24.9	55	1,369	11,660
" , Cherry	70	70		22.6	340	7,684	537
Misc. Vegetables	700	700		--	--	1,143	800
Total	15,575	7,875	7,700				24,480
Field							
Alfalfa	230	230		5.2	60	312	72
Irr. Pastures	1,500	700	800	--	--	150	225
Sugar Beets	2,120	1,120	1,000	31.0	28	868	1,840
Total	3,850	2,050	1,800				2,137
Grand TOTAL	39,809	27,209	12,600				41,970

* Based on 1975 Agricultural Commissioners Report

Irrigated crops grown in this area include at least 6 orchard crops, 23 vegetables, and 3 field crops. Agricultural gross income from these crops was $42 million in year 1975. (Table 2)

Farmers irrigate the crops by the pumping ~~of~~ from the ground water reservoir. Water quality is excellent: very low salt and boron content and the absence of any harmful constituents charaterizes this water. Natural recharge occurs to the ground water reservoir from the surrounding hills at the edge of the valley. In addition to the natural recharge, artificial recharge is practiced by the Santa Clara ~~County~~ Valley Water District. Local and imported water is used for this purpose. This practice stablizes the water table and continues to provide excellent quality water to all users. Among others, it enables the farmers to grow a wide variety of high producing and salt sensitive crops.

1.2 Wastewater Quality (Case A)

General

Quality of reclaimed water is determined by the a) quality of water before use, b) chemicals added to the water, c) degree of treatment. Water which is intended for urban use normally contains a small amount of salts and contains no toxic substances. Urban use, which is primary household use, adds approximately 300 ppm salts to the water. In areas where "water softeners" are still in use, harmful amounts of sodium are also added. The use of certain boron containing detergents can raise the level of this element to concentrations which are toxic for plants. Trace metals also increase during use; however, the kind of metal and its concentration varies at each location. Additional water contamination may occur where the water runs through leaking sewer lines. This condition often unnecessarily increases the salts in the wastewater.

Treatments of the sewer water reduces the microorganisms in the effluent and also causes the trace metals to fall out. However, the major salts stay in the water and continue to degrade its quality.

Treatments which remove major salts are usually an order of magnitude higher in cost than agriculture can pay for irrigation water.

1.3 Salinity

General Effects

Salinity adversely affects plants when the salt content in the soil increases to harmful levels. In irrigated fields the salts are added to the soil with the water. Plants take up and transpire the water through the leaves, which leaves the salts behind in the soil. If this process is not interrupted the soil becomes saline and unsuitable to grow crops. To prevent salinization, the leaching of the salts down and out of the root zone must be accomplished through the application of additional water. Leaching must be applied in regular intervals in order to maintain salt balance in the soil.

Soils irrigated with saline water must have good drainage where the downward movement of salts is not impeded. In general, irrigation with a higher salinity water requires more careful management, work and more water than irrigation with a good to excellent quality water.

TABLE 3

CASE A

PROJECTED COMPOSITION OF THE SAN JOSE-SANTA CLARA WASTEWATER

Major Constituents	Symbol	Unit	Concentration Normal	Maximum	Minimum
pH			7.6	8.0	7.0
Total Dissolved Solids	TDS	ppm	860	1000	733
Electrical Conductivity	EC	mmhos/cm	1200	1500	940
Calcium	Ca	meq/l	1.6	3.25	1.1
Magnesium	Mg		.58	2.17	.58
Sodium	Na		7.39	7.56	7.0
Potassium	K		.28	.43	.28
Sulfates	SO_4		2.54	2.54	2.41
Chlorides	Cl		5.65	7.34	5.33
Carbonates	CO_3				
Bicarbonates	HCO_3		4.91	4.91	3.27
Boron	B	ppm	.75	.9	.7

Trace Metals		ppm			
Aluminum	Al	ppm	.5	5.4	1.4
Arsenic	As	"	<.0008	.05	.0001
Beryllium	Be	"	ND	ND	ND
Cadmium	Cd	"	<.002	.002	ND
Cobalt	Co	"	ND	ND	ND
Chromium	Cr	"	<.032	.032	.005
Copper	Cu	"	<.11	.11	.01
Flouride	Fl	"	1.0	ND	.5
Iron	Fe	"	0.3	ND	.22
Lithium	Li	"	ND	ND	ND
Lead	Pl	"	<.017	.02	.0065
Magnesium	Mn	"	.2	ND	.09
Nickel	Ni	"	<.061	.061	.005
Ln	Ln	"	<.114	1.3	.045
Molybdenum	Mo	"	.02	.05	
Silenium	Se	"	ND	ND	ND
Vanadium	Va	"	ND	ND	ND

ND = No Data -- It is expected that all levels will meet criteria set for trace metals in waters used continuously on all soils. Natural Academy of Science, Water Quality Criteria 1972.

Health regulation standards will be met for sprinkler irrigation of food crops.

Salinity levels in the soil which result from irrigating with a certain water varies under various soil conditions and management practices. USDA Agriculture Handbook 60 states: "It was found ... that the ECe ranges from 2 to 10 times higher as the conductivity of the irrigation water." In this range good and poor conditions are included. Under optium conditions conductivity may increase as little as 1.5 times from the irrigation water to soil extract.

Yields for the Santa Clara Valley, when irrigated with wastewater were calculated assuming a 2 fold and a 3 fold increase in conductivity. For calculating gross income the midpoint of these two values was used.

Salt Tolerance of Crops

Individual crops tolerate salty conditions to a widely different degree. In general, as a group, orchards are the most salt sensitive. Vegetables are slightly more salt tolerant than orchards. Field crops are the most salt tolerant.

Salt tolerance of crops is correlated with the salt content of the soil saturation extract. This is normally measured and reported as the electrical conductivity of the extract (ECe).

Table 4 shows the crops of the study area and the salinity levels (ECe) at which certain yield declines occur.

Table 4

SALT TOLERANCE OF CROPS*

Yield Drecement Crop/Orchards	0% ECe	10% ECe	25% ECe	50% ECe	Maximum ECe
	mmhos/cm				
Apricots	1.6	2.0	2.6	3.7	6.0
Cherries	1.5	2.1	2.9	4.3	7.0
Grapes	1.5	2.5	4.1	6.7	12.0
Pears	1.7	2.3	3.3	4.8	8.0
Prunes	1.5	2.1	2.9	4.3	7.0
Walnuts	1.7	2.3	3.3	4.8	8.0
Strawberries	1.0	1.3	1.8	2.5	4.0
Vegetables					
Beans, Snap	1.0	1.5	2.3	3.6	6.5
Broccoli	2.8	3.9	5.5	8.2	13.5
Cabbage	1.8	2.8	4.4	7.0	12.0
Cucumber	2.5	3.3	4.4	6.3	10.0
Corn	1.7	2.5	3.8	5.9	10.0
Garlic	1.2	1.8	2.8	4.3	7.5
Lettuce, Head	1.3	2.1	3.2	5.2	9.0
Onions	1.2	1.8	2.8	4.3	7.5
Peppers, Bell	1.5	2.2	3.3	5.1	8.5
Spinach	2.0	3.3	5.3	8.6	15.0
Squash	2.5	3.3	4.4	6.3	10.0
Tomatoes, Fresh	2.5	3.5	5.0	7.6	12.5
Field					
Alfalfa	2.0	3.4	5.4	8.8	15.5
Irr. Pastures	6.0	7.4	9.5	13.0	20.0
Sugar Beets	7.0	8.7	11.0	15.0	24.0

*Yield decrement to be expected due to salt content in the soil (ECe).
Source: Water Quality for Irrigation FAO UN Rome, 1976

Effects of Salinity in the Santa Clara Valley

The elevated salt content of the wastewater would affect many crops in the area. Yield losses which would result from salinity were estimated in Table 5. It should be noted that strawberries, bushberries, mushrooms, flower and vegetable seed producing areas were omitted from the calculations. These are highly salt senstive crops and a small increase in salinity would result in a higher gross income loss than in the case of other crops.

Fruit and nuts are the next salt sensitive crops grown in this area. Wastewater irrigation could cause more than 30 percent decline in ochard crop yields. This is a income loss of $260 per acre. It represents $4.4 million loss over the 17,000 acre ochard area.

Vegetable crop decline would be approximately 18 percent. This is a gross income loss of $300 per acre to the farmers. Considering the 7,800 acre vegetable crop area, $2.3 million would be lost from the gross agricultural return of this area. Among vegetable crops which occupy 100 acres or more such as beans, garlic and peppers would be most affected. Least effect would occur to tomatoes which are fairly salt tolerant among vegetables.

Field crops would not be affected in any significant way by salinity; only alfalfa would suffer a small yield loss.

1.4 High Sodium

Adjusted sodium ratio (adj. SAR) indicates the sodium and bicarbonate concentration of the water in proportion to other constituents. It is calculated by using the following formula:

$$\text{adj. SAR} = \frac{\text{Na}}{\sqrt{\frac{\text{Ca+Mg}}{2}}} \quad [1 + (8.4 - \text{pHc})]$$

Where pHc is a theoretical calculated pH of the irrigation water in contact with lime and ~~in contact with lime and~~ in equilibrium with soil CO_2.

Waters with elevated adj. SAR will affect the clay fraction of the soil and alter the soil structure. Among clays which are common in soils, the Montmorillonite type is first affected by high adj. SAR waters. Illite-Vermiculite clays are somewhate less affected.

Permeability is reduced in soils which are irrigated with high adj. SAR waters. Under such conditions, many more problems develop which are associated with poor drainage conditions. Elsewhere in California, large land tracts were rendered totally barren by irrigation with this type of water. Reclamation of these soils is difficult and expensive.

Projected quality for the wastewater indicates that it will have 9.05 adj. SAR. It will cause increasing problems in soils which contain Illite-Vermiculite and severe problems with Montmorillonite clays.

Soils containing Montmorillonite clays are common in agricultural soils. In the Santa Clara Valley, out of 70 soils the majority (62) contain this clay type in excess of 18 percent of the clay fraction. Prolonged use of this waste water undoubtedly would create serious problems on some of these soils.

Table 5
Effect of Salinity on Agricultural Gross Income

Crop	Acres	Gross Income ($1000)	Yields at Salinity-Levels (1)	(2)	(3)	Gross Income ($1000)	Loss of Income (per Acre/$)	Loss Incor $/Acre
Orchards								
Apricots	2,419	3,527	.76	.45	.6	2,116	1,411	583
Cherries	721	1,284	.76	.45	.6	770	514	712
Grapes	1,834	1,251	.9	.52	.71	888	363	197
Pears	1,474	1,360	.85	.62	.73	966	394	267
Prunes	7,342	3,928	.8	.55	.67	2,632	1,296	174
Walnuts	3,104	943	.85	.6	.72	679	264	85
Misc. Orchards	390	600	.85	.5	.67	402	198	507
Total	17,284	12,893	.82	.518	.65	8,453	4,440	260
Vegetables								
Anise	10	16	.7	.5	.6	10	6	600
Beans, Snap	335	566	.7	.45	.57	396	170	508
Broccoli	50	36	.1	.88	.94	34	2	40
Cabbage	70	51	.95	.55	.7	36	15	272
Cauliflower	55	53	.8	.65	.72	40	13	236
Chinese Vegetables	660	1,188	.8	.65	.72	855	333	504
Corn	240	214	.9	.7	.8	171	43	179
Cucumber	440	739	.98	.8	.89	658	81	184
Endive	40	43	.8	.65	.72	31	12	300
Garlic	500	993	.78	.52	.65	645	348	696
Lettuce, Head	425	527	.8	.7	.75	395	132	310
Lettuce, Leaf	390	391	.8	.7	.75	293	98	251
Lettuce, Romaine	90	94	.8	.7	.75	70	24	266
Mustard	50	52	.95	.8	.87	45	7	140
Onions	305	1,378	.78	.52	.65	895	483	1,583
Peppers, Bell	360	520	.8	.65	.73	369	151	419
Peppers, Chili	315	759	.8	.65	.73	530	221	701
Spinach	80	134	.98	.8	.89	119	15	187

Table 5 Continued

Table 5 Cont'd

Crops/Vegetables	Acres	Gross Income($1000)	Yields at Salinity-Levels*			Gross Income ($1000)	Loss of Income $1000.	Loss Income($/Ac.
Cont'd			(1)	(2)	(3)			
Squash	105	133	.98	.8	.89	118	15	142
Tomatoes, Fresh	85	373	.1	.85	.93	347	26	305
Tomatoes, Processed	2,500	3,422	.1	.85	.93	3,182	240	96
Tomatoes, Cherry	70	538	.1	.85	.93	500	38	542
Misc. Vegetables	700	800	.85	.7	.77	616	184	263
Total	7,875	13,020	.876	.7	.79	10,363	2,657	300.
Field								
Alfalfa	230	72	.98	.85	.91	65	7	30
Irr. Pastures	700	105	.1	.1	.1	105	0	--
Sugar Beets	1,120	972	.1	.1	.1	972	0	--
Total	2,050	1,149			.996	1,142	7	3
Grand Total	27,209	27,062			.74	19,958	7,104	

*(1) Assumed that $EC_w \times 2 = EC_e$

(2) Assumed that $EC_w \times 3 = EC_e$

(3) Arithmetical average of 1 and 2.

High adj. SAR waters occasionally can be effectively treated. Addition of gypsum reduces the adj. SAR. However, this treatment increases the salinity of the water which is highly undesirable for the Santa Clara Valley agriculture.

1.5 Specific Ion Toxicities

Sodium, chloride and bicarbonate ions will be present in higher than desirable concentration in the wastewater. The projected concentrations and the corresponsing guideline levels are shown for these ions in the following table.

TABLE 6

Effects of Specifications*

		Degree of Problem		
	Projected Concentration	No Problem	Increasing Problem	Severe Problem
Ion	meq/l	meq/l		
Sodium (Na^+)	7.4	3	3.9	9
Chloride (Cl^-)	5.6	4	4.10	10
Bicarbonates (HCO_3^-)	4.91	1.5	1.5 - 8.5	8.5

Sodium and chloride in the soil affect tree crops only. Tree crops of the area will be eliminated by salinity, before any sodium problem could develop. However, if the water is used for sprinkler irrigation, leaf burns could be caused by levels over 3 meq/l.

The bicarbonate concentration is also excessive; water with this concentration of HCO_3^- is unsuitable for irrigation. This ion also causes the burning of leaves and aggravates sodic conditions (see 1.4).

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*Water quality for irrigation FAO UN Rome 1976

The projected normal and maximum boron concentrations in the wastewater are 0.75 and .9 ppm respectively. No adverse affects of boron to crops are expected at .75 ppm or below. The .9 ppm level could have slight effect on boron sensitive crops. In the project area these crops are apricots, cherries, grapes, pears, prunes, beans, and walnuts. However, these crops would be eliminated by the salinity of the water before boron problems could develop.

1.6 Expected Losses to Farmers

Should wastewater of the projected quality be applied for irrigation of crops, agriculture would change in the study area. Farmers would have to grow crops which tolerate the conditions created by this water, or, on some land, abandon farming. Some of the effects which would result from this irrigation practice are mentioned below.

Bearing young fruit tree stands which grew in this area, were valued at \$1237 to \$2645 per acre. Grape stand was valued at \$885 per acre (University City of California Agr. Ext. Ser. Publication 1968). If no other condition prevailed, salinity or alkalinity would force the farmers to pull the trees or abandon cultivation. In either case, the loss in tree stand could be \$25 million in the study area. This is estimated by using a \$1,500 per acre tree stand value and 17,000 acre orchard area. The loss may be less if some orchards under optimum conditions could survive. However, a \$1,500 per acre loss to the individual farmer is intolerable.

Many vegetable crops could not be grown in the area. It is impossible to predict which crops would replace them. Tomatoes and sugar beets are relatively salt tolerant, however, they are grown under contract and an increase of this magnitude may effect availability of market for these commodities.

Farmers in this area usually grow 2 to 3 crops. For these crops they have the facilities and specialized machinery which is needed for profitable operation. Farmers also have the all-important know-how to grow the crop. Forced change from the present crop would induce the loss of these values, and require new capital expenditures to replace them. As a general rule capital investment for equipment constitute a large part of farming cost (25 to 30%). While the numerical losses cannot be estimated at this time, to many individuals, they will undoubtedly be high.

1.7 Irrigation With Case C Wastewater

Salt removal from the wastewater would result in water composition as shown in Table 7. This composition indicates that water quality is good, salt and all individual constituents are within the safe limits.

No adverse effect should result to agriculture if this water is used to irrigate crops and the following conditions are provided

- Wastewater cost would be equivalent to present water cost (less than $20. per acre ft., including pumping).
- Wastewater delivery system would be tied into the farm irrigation systems.
- Treatment process would be accident-proof. Good quality and uncontaminated waste water would be available to the farmers whenever needed.

In the Santa Clara Valley, the present irrigation water is satisfactory. Above conditions alone would not provide incentive to the farmer to irrigate with waste water.

TABLE 7

CASE C

PROJECTED COMPOSITION OF THE SAN JOSE - SANTA CLARA WASTE WATERS

Major Constituents	Symbol	Unit	Normal
pH			
Total Dissolved Solids	TDS	ppm	400
Electrical Conductivity	EC	umhos/cm	600
Calcium	Ca	meq/l	1.
Magnesium	Mg	"	.25
Sodium	Na	"	3.47
Potassium	K	"	
Sulfates	SO_4	"	1.87
Chlorides	Cl	"	2.28
Carbonates	CO_3	"	
Bicarbonates	HCO_3	"	1.47
Boron	B	ppm	.75

Trace Metals and Health regulation criteria are the same as in Case "A"

2.0 SAN BENITO COUNTY

Summary of Effects

- Land reclamation needed in the San Benito County's Bolsa area would require the construction of drainage system. Effects, of drain water discharge of such system on the Pajaro River water should be explored.
- Wastewater quality "Case A" is not acceptable for land reclamation or irrigation. However, if the concentration of Na, HCO_3 and Cl are lowered the water is suitable for irrigation.
  "Case C" quality water would also be acceptable.
- Drainage construction coupled to wastewater irrigation could provide incentive to farmers to use waste water.

2.1 Agriculture and Water Supply

In San Benito County, the principal agricultural area lies in the northern part of the county. Intensive farming is practiced on the flat alluvial soils of Hollister Valley, Fairview District, San Jual Valley and the Bolsa area. Principal crops of the county include a variety of fruits, nuts, vegetables and field crops. Where water is available, the land is irrigated. Farming is the main source of income in the county; gross agricultural income exceeded $64 million in 1975. Fruits, nuts, vegetables and field crops occupied 74,000 acres. Range land was 508,000 acres.

Irrigation of agricultural crops in the San Benito County started about 100 yrs. ago. Wells were drilled into the ground water reservoir which underlies the land. The first wells in the San Felipe area were artesian. As water use increased and the ground water was depleted pumping became necessary. It is estimated that water withdrawal exceeds the natural recharge by 7000 acft. every year, requiring the deepending of the wells and pumping from greater depths. It is estimated that since the start of water withdrawal, water levels have declined 180 ft. in the wells.

Ground water conditions in this area are affected by the complex geology. Three ground water subbasins and two or more subunits for each subbasin are formed by under ground faults. The San Andreas rift zone, the Ausaymas fault, the Calaveras fault and other faults affect the flow of ground water throughout the basin.

Quality of the water varies in the area. In general, deepening of the wells brings up saline water. In some locations, toxic boron concentration makes the water unsuitable for irrigation. Because of these conditions some wells have had to be abandoned.

Problems related to irrigation water supply has long been recognized in the county. Since 1955, San Benito has participated in a series of engineering and economic studies on water importation projects. Now it is strongly hoped in the county that the majority of its agricultural land will receive water from the San Felipe project. This will be excellent quality water and will correct the agricultural problems which are related to irrigation in that area.

The area which will not receive San Felipe water lies in the northeast part of the county. It is known as the Bolsa. It is bordered from the east by the Hollister-San Felipe road, from the west by the Pajaro River and from the south by the Lomerias Muertas hills.

In the following paragraphs, waste water irrigation will be considered in the Bolsa area.

2.2 The Bolsa Area

In the Bolsa there are approximately 20,000 to 22,000 acres of arable land. It is an almost completely flat area which slopes slightly toward the Pajaro River in the west. This river is the drain outlet of the entire basin.

Soils in the Bolsa belong to the Clear Lake - Pacheco-Willows soils association. These are nearly level poorly drained soils that formed in alluvium derived from sedimentary rocks. Plant cover of the natural vegetation, where not removed by farming, consists of grasses,forbs and salt tolerant plants. The soils are generally fine textured.

The Clear Lake soils consist of poorly drained, very dark gray clays underlain by drak-gray clay over gray clay. These soils are in basins. The Pacheco soils are on flood plains and are poorly drained. They have a drak-gray silt loam surface layer and a grayish-brown clay loam subsoil. The Willows soils occur in basins and are poorly drained and saline-alkali. They have a grayish-brown clay surface layer underlain by light yellowish-brown clay.

In addition to the above three soils the Metz, Rincon and Cropley soils also occur in smaller areas. Soils of this association are intensively cultivated to row and field crops, alfalfa, and small grains. Fruits and nuts are grown in areas that have been drained. Drainage is needed in most areas, and reclamation is needed in areas affected by salts and alkali.

Saline conditions affect most soils of the Bolsa. This condition is caused by the poor drainage of the soils and the use of saline irrigation water. Electrical conductivity of monitored well waters ranges from 750 to 2250 umhos per cm.

Salinized fields are not confined to any region, but occur scattered over the entire area. It is estimated that land which is not cultivated due to salty conditions could be as much as 3500 acres.

Symptoms of saline conditions are easily seen in most of the area. Fields lying lower than the surrounding area are not cultivated, but are covered with grasses and other salt tolerant plants. In barley fields, large barren spots indicate where the seed failed to germinate because of saline conditions. Some spots are covered with white salt crystals where capillary action brought the salty water to the surface.

Systematic survey of these conditions has not been yet performed for the area. However, at several locations, highly saline soils conditions are found (ECe = over 25 MMhos per cm).

Perched water affects a large portion of the area. This water is unrelated to the main ground water table which is at considerable depth. The condition is caused by the low permeabiltiy of the subsoils which prevent deep water percolation. In perched water table areas the water often rises to the surface by capillary action and causes salinization of the upper soil layer. Fluctuations in the perched water level are caused by irrigation of crops. Conditions in this area appear to be similar to the perched water of the southern lake beds in Kern County, California.

Fifteen crops are grown under irrigation in the Bolsa. Approximately half of the acerage is in tomatoes. Sugarbeets, lettuce, alfalfa, asparagus, pepper, and walnuts occupy approximately 500 to 2000 acres each. Corn, sudan grass, permanent pasture, onion, garlic, califlower, appricots and cherries are grown on small acerages.

2.3 Land Reclamation, Drainage

Land reclamation would require the construction of a drain system in the Bolsa. This system should include the installation of drain pipes in the field and closed pipes to the point where the drain water can be discharged.

Drainage system was recently installed on a smaller area (280 ac) elsewhere in San Benito County. The cost was approximately $180 per acre. This cost would be within the limit what agriculture can pay for drainage construction.

However, the discharge of drain water would create a difficult problem. For the entire basin,the Pajaro river is the drain outlet, and discharge from drains into the river would degrade its quality. Downstream water users and environmental considerations may prevent such practice. An acceptable solution to this problem probably must circumvent a design which discharges directly into the Pajaro.

The presently available irrigation water is not well suited for land reclamation.

2.4 Wastewater Irrigation

Feasibility of wastewater irrigation in this area should be further explored. At present only general information is available on many important subjects. However, based on such information, it appears that wastewater irrigation may be feasible under the following conditions:

1) "Case A" quality water, because of the high adj. SAR bicarbonates and chlorides, is not suitable for land reclamation or irrigation. However, its salinity level would be acceptable in this area. If the objectionable ions (Na, HCO_3, Cl) are reduced the water would be acceptable for the Bolsa.

"Case C" water would be also acceptable quality.

2) Drain system would be constructed for the affected areas. Farmers could pay at least for a portion of the cost if some feasible way is found to discharge drain water from the basin.

3) Farmers would be contracted to irrigate with waste water in return for assistance they receive in drainage construction. The price of waste water to farmers should be comparable to irrigation water prices elsewhere.

Determining feasibility of such project would require substantially more information on the following subjects:

- Present productivity of the area and potential productivity under wastewater irrigation.
- Exploration of the possible and the most feasible methods of drain water discharge from the basin and the cost of a drain system.
- Cost of improvement in quality Case A wastewater (reduction of harmful ions).
- Cost of water delivery system.
- Acceptability of this program to farmers.

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University of California
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San Benito County

U. S. Department of Agriculture
Soil Conservation Service
Davis, California

U. S. Department of Agriculture
Soil Conservation Service
Hollister, California

U. S. Department of Agriculture
Salinity Laboratory
Riverside, California